Determinants of User Acceptance of In-Home Monitoring Technologies for Persons with Dementia (PwD)

Annika Köster
Department of Behavioural, Management and Social Sciences, University of Twente
1st Supervisor: Dr. Annemarie Braakman-Jansen
2nd Supervisor: Christian Wrede
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Abstract

Background: Dementia is the fastest-growing cause of disability and dependency among older people worldwide. But in contrast to that, the number of professional caregivers and residential care possibilities is not expected to grow as fast. This situation puts a bigger emphasis on informal care for people with dementia. A consequence of that is the burden it places on informal caregivers, who often suffer from mental and physical health consequences, as well as social consequences in their private life, due to their care responsibility. In-home monitoring technology has the potential to improve the care situation by giving the informal caregiver the possibility to monitor the person with dementia (PwD) from a distance, which would decrease the burden on them and would allow the PwD to stay in their home for longer. However, this is dependent on a successful implementation. For this to succeed it is necessary to use a user-centred design approach and to take future users into account during the development process. Therefore, it is important to conduct research on their current acceptance of different monitoring-technologies and different monitoring activities. Additionally, it needs to be researched which factors are associated to user acceptance and therefore could lead to a successful implementation. In this regard this study will focus on the factors from the Technology Acceptance Model (perceived benefits and attitude) and the factors perceived barriers and general perception towards technology in order to see how and if they are associated to user acceptance.

Methods: A cross-sectional quantitative study was conducted online with 66 participants from the general German public. The participants were recruited via non-probability, convenience sampling. A questionnaire was created in order to determine the participant's acceptance towards different monitoring technologies, namely wearables, visual-based-, audio-based- and radiofrequency-based monitoring technologies. Additionally, the participant's acceptance towards different monitoring activities was measured. These were: Activity of daily living, Instrumental activity of daily living, Ambulatory Activity, Mental functions and Physiological activity. Furthermore, it was determined if the factors "Perceived benefits", "Attitude towards monitoring technology" (factors from the Technology Acceptance Model) and "Perceived barriers" and "General perception towards technology" are associated with user acceptance.

The program SPSS was used to conduct the analyses. The data was analysed by using descriptive statistics and Pearson's correlation coefficient.

Results: The sample consisted of 66 participants of which 76% were female and 24% were male. The mean age was 31.73 (*SD*=13.07) and most participants (50.76%) did not fulfil a care role. The results showed that the mean acceptance rating for radiofrequency-based monitoring technology over all participants was slightly negative (*M*=2.86, *SD*=1.04). It was also found that the highest acceptance of monitoring was found for the monitoring of "physiological activity" (*M*=3.91, *SD*=1.13), while "activity of daily living" scored lowest (*M*=2.33, *SD*=1.13*)*. Furthermore, Pearson's correlation analysis showed that a significant relationship exists between "Perceived benefits" and "User acceptance towards radiofrequency-based monitoring technology" (*r*=0.27, weak correlation). Another significant relationship was found between "attitude towards monitoring technology" and "User acceptance towards radiofrequency-based monitoring technology" (*r*=0.36, moderate correlation). No significant relationship was found between "User acceptance towards radiofrequency-based monitoring technology" and "Perceived barriers" or "General perception towards technology". Another finding was that the participants were very concerned that their data could be given/retrieved to/by third parties (*M*=4.23, *SD*= 0.82) and the general misuse of their data (*M*=4.21, *SD*=0.92).

Conclusion: In this study a slightly negative acceptance score was found for radiofrequency-based monitoring technologies. This means it would be beneficial to conduct further research on the reasons and motives behind a relatively low acceptance in form of a qualitative questionnaire or interviews. Furthermore, this study showed that people are very concerned about their privacy and the data protection, which was also found to be true in many other studies. This means that more research needs to be done about how to improve the safety of the data of monitoring technologies. Also, in this matter user centred design should be used to create safety measures that appeal to the user and makes them feel comfortable using a monitoring technology. It might also be interesting to conduct another study similar to the current one with an on average older or a bigger and more diverse sample, in order to compare the outcomes to the current study to determine if the outcome would be different and therefore might be dependent on age. Furthermore, it could be checked again if in an older or more diverse sample the factors "Perceived barriers" and "General perception towards technology" were associated with "User acceptance of radiofrequency-based monitoring systems". So overall, more research needs to be conducted in many areas of home-

monitoring technology, and it is important to use a user-centred design approach to take the future user into account in order to ensure a development of a product which fulfils the needs of the users and that they feel safe and beneficial using.

Introduction

According to the Organisation for Economic Cooperation and Development (OECD) (2015) the current society is aging faster than ever. In their book they show that in Japan in 1990 the percentage of over 80-year-olds was around 2.4%, in 2020 it was already at around 10% and it is expected to grow up to 16.5% until the year 2050. This drastic increase of elderlies in the population comes with a number of problems. An important aspect is the increasing prevalence of age-related disease and disabilities (National Institute of Aging, n.d.). Some other factors influenced by the growth of the elderly population are economic growth, patterns of work and retirement and the ability of the government to provide fitting care and resources for elderlies (National Institute of Aging, n.d.).

One of the diseases of which the prevalence is expected to grow drastically is dementia. At this point in time 50 million people worldwide suffer from dementia and this number is expected to triple until the year 2050 (European Parliamentary Technology Assessment, 2019; World Health Organisation, 2020). This makes it the fastest growing cause of disability worldwide and so far, there was no cure found (OECD, 2015). Dementia is described by the World Health Organisation (2020) as "a syndrome – usually of a chronic or progressive nature – in which there is deterioration in cognitive function (i.e. the ability to process thought) beyond what might be expected from normal aging". There are several forms of dementia. The most common one is Alzheimer's disease (60-70% of all cases) (World Health Organisation, 2020). Other common variations are vascular dementia (around 30% of all cases), dementia with Lewy bodies and several others which lead to a degeneration of the frontal lobe (Fratiglioni et al., 1999; World Health Organisation, 2020). The boundaries between these types of dementia are not clearly definable and the types are often co-existing (World Health Organisation, 2020).

Dementia progresses in stages, which means that the symptoms become more severe over time (World Health Organisation, 2020). The onset of the disease is characterized by a slow progressive development of symptoms such as forgetfulness, losing track of time and becoming lost at familiar places (World Health Organisation, 2020). Symptoms of the middle stage are becoming forgetful towards recent events and names, becoming lost at home, increased difficulty in communicating with others, increased need for help with personal care and behaviour changes, such as wandering aimlessly or repeating questions (World Health Organisation, 2020). In late stages of dementia, the person with dementia (PwD) becomes heavily dependent on others and

becomes more and more inactive (World Health Organisation, 2020). At this stage the memory loss is severe and symptoms such as being unaware of time and place, finding it difficult to recognize relatives and friends, need intense support in self-care, difficulties walking and major behaviour changes, such as aggression are often experienced (World Health Organisation, 2020).

Due to these physical and cognitive consequences, people with dementia become increasingly restricted in their abilities to live their lives safely and independently (Zwaanswijk et al., 2013). Additionally, people with dementia often suffer from stigma about their disease, which leads to others acting towards them with prejudice which reduces the quality of their social life (Alzheimer's Disease International, 2019). Overall, they are more dependent on others, which often comes with a feeling of guilt and the feeling of being a burden to their caregiver(s) (Urwyler et al., 2017; Zwaanswijk et al., 2013).

With the wish of many elderlies to live at home as long as possible and the insufficient growth in the number of professional caregivers and residential care possibilities, existing professional care givers are facing an increased workload and an increasing complexity of care, which requires a more effective use of their resources (Wrede et al., 2021; Zwaanswijk et al., 2013). This situation also places a bigger emphasis on informal care for people with dementia (Zwaanswijk et al., 2013). This often leads to mental and physical health consequences, such as depression or an increased stress rate, which can also lead to stress-related illness (Alzheimer's Disease International, 2019; Wrede et al., 2021). Informal caregivers also often report that their social life suffers under their care responsibility (Alzheimer's Disease International, 2019). Since dementia is a disease which progresses over multiple years, these consequences can become a serious problem for the informal caregiver and puts them at risk of becoming a so-called "invisible second patient" (Wrede et al., 2021).

One way that could help to let people with dementia stay longer in their homes, without damaging the health of informal caregivers would be to implement eHealth technologies into the care of people with dementia. eHealth in general can be defined as "an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the internet and related technologies" (Eysenbach, 2001). One example of eHealth technology are home-monitoring technologies. These could be used in the care of people with dementia in order to optimize the care. Home-monitoring systems would enable the informal caregiver to monitor the health and safety of the PwD from a distance,

which would decrease the burden on them and therefore also the mental and physical health consequences (Mihailidis et al., 2008). Additionally, it would allow the PwD to continue to live independently in their home, while also being more safe (Mihailidis et al., 2008). This would also mean that the PwD would not need to live in a residential care home and would therefore not be completely dependent on professional caregivers, which means that the pressure on professional caregivers would also be reduced.

Depending on what kind of activity should be monitored there are different design solutions. For example, some systems focus on physiological activities such as sleeping, while other systems focus more on physical activities such as falling (Hussain et al., 2019). Besides this there are also different types of sensors, which are used for the different systems. These all have different advantages and disadvantages, but some of them are often perceived as more intrusive than others (Hussain et al., 2019). The first example are sensors which are worn directly on the body in form of wearables, such as different health & physiological monitoring systems, which come in form of bracelets or smartwatches and measure physiological data (e.g. information about sleeping pattern or heart rate) (Hussain et al., 2019). On the one hand, these systems are able to provide very accurate data about the physiological activity of the user and are not bound to the home environment (Hussain et al., 2019). Additionally, these kinds of devices were mostly seen as relatively unintrusive (Hussain et al., 2019). On the other hand, the user needs to remember to wear it and there is always a risk of losing the device (Hussain et al., 2019). Other systems, such as vision-based systems, audio-based systems and radiofrequency-based systems are using sensors which are attached in the home-environment of the users (Hussain et al., 2019). An example of vision-based systems are cameras which capture their surrounding 24/7 (Hussain et al., 2019). An example for audio-based systems are smart speakers (Hussain et al., 2019). These two systems have the advantage that they offer coherent data, which is easy to understand for the caregiver (Mihailidis et al., 2008). The major disadvantage of them according to Berridge and Wetle (2020) is the obtrusiveness and invasion of privacy of the PwD that comes with this system. This can become especially problematic in cases of a privacy breaching where the data is retrieved by third parties (Berridge and Wetle, 2020). Lastly, an example for radio frequency-based sensing systems would be “activity of daily living prompting”, which monitors the completion of basic daily activities, such as eating, toileting or brushing teeth and gives reminders to conduct these activities (Mihailidis et al., 2008). These have the advantage that they can be interpreted as less intrusive,

since the system does not record every activity, but only records and forwards data about specific tasks (Hussain et al., 2019). However, the disadvantages of these types of technologies are that the sensor ranges are mostly either too small (does not cover large areas in the environment) or too big (meaning it also measures the neighbours) and they are relatively susceptible to environmental interference (Hussain et al., 2019).

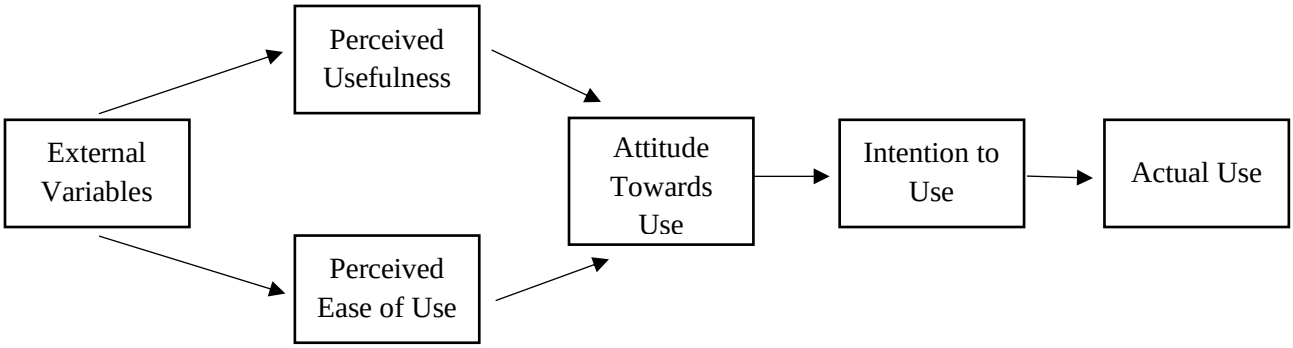
Besides the benefits eHealth and home-monitoring systems could have for people with dementia and their caregivers, they also come with some ethical barriers and implementation issues (van Gemert-Pijnen et al., 2018). The issue with the implementation of eHealth technologies is that they are often not continued to be used after the first implementation (van Gemert-Pijnen et al., 2018). Some reasons for that are that the users often do not feel motivated enough or do not see enough benefits in the technology to continue to use it (van Gemert-Pijnen et al., 2018). Issues related to ethics are that people often feel that the process of storing and sharing of data is out of their control (van Gemert-Pijnen et al., 2018). Furthermore, they have concerns about privacy and security and are often wondering about who is actually owning their data and if it is possible that companies are selling their data (van Gemert-Pijnen et al., 2018).

In order to increase the probability of a successful implementation of home-monitoring technologies it is important to use a user-centred design approach. This can be defined as "the process of building insights about users' experience through usability testing and other forms of user research into product development through an iterative design process" (Barnum, 2020). In the development of in-home-monitoring technologies, it is also important to take the future users (people with dementia and informal caregivers) into account in order to develop home-monitoring systems which fulfil their purpose without being intrusive or making the user feel unsafe about their data. Since many home-monitoring technologies are still in development it is important to work together with future users and to find out what they want and do not want in a home monitoring system. Since these future users are both people who have or will have dementia, and people taking care of PwD now or in the future, the views and opinions of the full general public should be taken into account. Especially important in this context is the question if they would accept to use certain home-monitoring systems if they themselves would be monitored by it, in order to create a more personal connection to the technologies and receive personal and honest opinions.

In order to determine the actual use of a technology the Technology Acceptance Model (TAM) can be used. This model states that external variables influence the perceived ease of use and the perceived usefulness (Aljarrah et al., 2016). These two factors determine the attitude towards use, which then determines the intention to use (Aljarrah et al., 2016). The intention to use finally determines the actual system use (Aljarrah et al., 2016). The complete model can be seen in Figure 1.

Figure 1

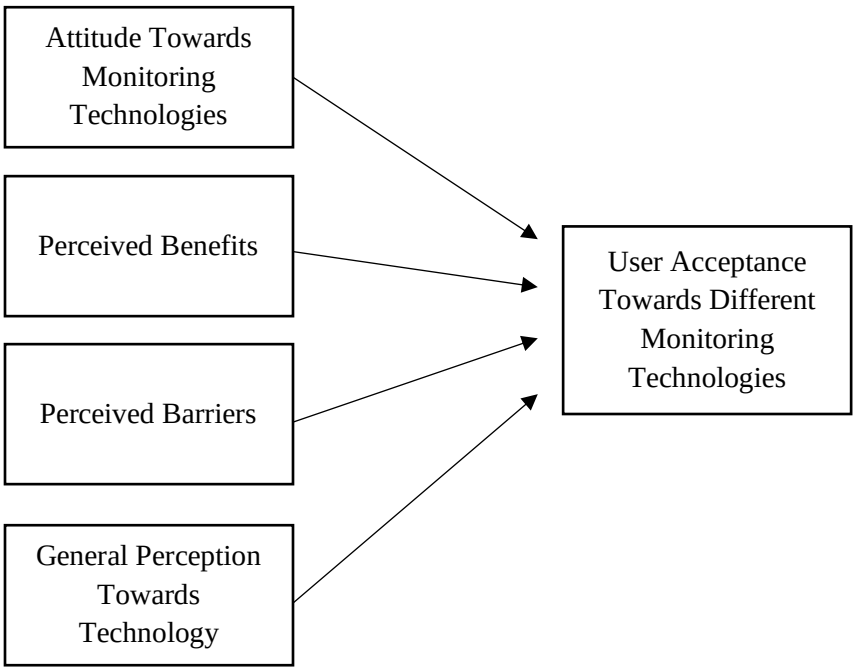
Technology Acceptance Model (TAM)



So, in order to achieve a continuous use, which is the goal of a successful implementation, it is necessary to conduct research on the perceived usefulness and perceived ease of use according to the TAM. But using the TAM also has some drawbacks, for example since many home-monitoring technologies are still in development the perceived ease of use cannot be determined yet. Furthermore, critics of the TAM are expressing that the TAM overlooks some important determinants for a continuous use. Peek et al. (2014) for example say that benefits such as increased safety and increased independence also play an important role next to perceived usefulness. Furthermore, he also mentions that barriers of monitoring technologies, such as possible health consequences or privacy concerns also are important to take into account (Peek et al., 2014). Moreover, it was found that general perception of technology and trust in technology are also important determinants (Cimperman et al., 2013; Peek, 2014). The proposed associated constructs and their effect can be seen in Figure 2.

Figure 2

Proposed Associated Constructs with User Acceptance Towards Different Monitoring Technologies



So overall, it can be seen that it is important for the development of in-home monitoring technologies to conduct research on the acceptability of different in-home monitoring technologies and on their acceptability for different monitoring activities. Furthermore, it is also important to look at which factors are associated with user acceptance, in order to be able to conduct more research on how to improve the acceptability in the future.

Research questions:

1) What is the user acceptance in general of the general German public towards radiofrequency-based in-home monitoring technologies for community dwelling elderlies?

2) What is the user acceptance of the general German public towards in-home monitoring technology for community dwelling elderlies for different monitoring activities?

3) To what extent are factors from the Technology Acceptance Model (perceived benefits and attitude towards monitoring technologies), perceived barriers and general perception towards technology associated with user acceptance towards radiofrequency-based in-home monitoring technologies for community dwelling elderly according to the general German public?

Methods

Design

A cross-sectional quantitative study design was used in order to examine the user acceptance in general of the general German public towards radiofrequency-based in-home monitoring technologies for community dwelling elderlies. Moreover, the user acceptance of the general German public towards in-home monitoring technology for community dwelling elderlies for different monitoring activities was examined. The third purpose of this study was to examine to what extent factors from the Technology Acceptance Model (perceived benefits and attitude towards monitoring technologies), perceived barriers and general perception towards technology are associated with user acceptance towards different in-home monitoring technologies for community dwelling elderly according to the general German public.

Participants

The inclusion criteria for this study were that the participants had to be at least 18 years old, and they needed to be German. The sampling procedure was non-probability sampling, more specifically convenience sampling. The recruitment was done via direct messaging by the researcher on the messaging platform “WhatsApp”. In the message sent, the contacted people were asked to distribute the questionnaire further, in order to increase the sample size via snowball sampling.

Materials

For this study a quantitative survey (Appendix A) was conducted. In the questions the participants were told to assume that they would be the ones that would be monitored by the home-monitoring technologies and state their opinion based on this. The collected background characteristics were: age, gender, nationality and level of digital literacy. All of these were

measured by single-item scales. All constructs were measured by multi-item scales. The x constructs are: Acceptance of monitoring towards different types of activities, Acceptance towards different types of monitoring technologies, General attitude towards monitoring technology, Perceived usefulness, Expected benefits of in-home monitoring technology, Privacy and security concerns, Expected barriers of in-home monitoring technology, general perception towards monitoring technology, General trust in technology and Personal innovativeness towards technology.

Background Characteristics

The age of the participants in years was asked. For their gender the participants had the options female, male and other. For their nationality the participants could choose between German, Dutch and other. In order to determine the participants level of digital literacy they were asked to rate their digital skills and ability to deal with technology on a scale ranging from 1 (=very poor) to 10 (=very well).

User Acceptance

Acceptance of Monitoring Towards Different Types of Activities

To measure the participant's acceptance of the monitoring of different types of activities they were given a list of five types of activities. For each of these the participants had to rate how acceptable they think it is to monitor that activity. There was one item for every kind of activity. The rating was done via a 5-point Likert scale ranging from 1 (= totally disagree) to 5 (= totally agree). For this they were asked to imagine that they themselves would be monitored during these activities and answer based on that. The mentioned activities were: activities of daily living, instrumental activities of daily living, ambulatory activity, mental functions, and physiological activity (Hussain et al., 2019). Examples for activities of daily living would be eating, dressing, and toileting, and for instrumental activities of daily living examples are: meal preparation, housekeeping and medication (Hussain et al., 2019). Ambulatory activity includes dynamic activities, such as walking inside-outside and running, stationary activities, such as standing, sitting and lying and transitional activities, for example from sitting to standing or from standing to walking (Hussain et al., 2019). Examples for mental functions are: memory, comprehension and orientation, and for physiological activity: cardiac activity, brain activity and breathing (Hussain

et al., 2019). The Cronbach's alpha of this scale is 0.76. This shows that this scale has an acceptable internal consistency.

Acceptance Towards Different Types of Monitoring Technologies

To measure which type of monitoring technologies are acceptable according to the participants they were asked to rate their acceptance for four different monitoring technologies on a 5-point Likert scale ranging from 1 (= totally unacceptable) to 5 (=totally acceptable). For each kind of technology there was one item. For this they had to imagine that they themselves would be monitored by them. The technologies were: wearable technologies (e.g. smartwatches), vision-based technology (e.g. surveillance cameras), audio-based technology (e.g. smart speakers) and radio frequency-based sensing systems (e.g. Wi-Fi radars) (Hussain et al., 2019). The Cronbach's alpha of this scale is 0.77, which means that the scale has an acceptable internal consistency.

Attitude Towards Monitoring Technology

General Attitude Towards Monitoring Technology

To measure the general attitude towards monitoring technology the participants were asked to state their opinion on seven statements about monitoring technologies on a 5-point Likert scale ranging from 1 (=totally disagree) to 5 (=totally agree). One example for a statement would be "I would not mind being monitored unobtrusively by sensors in my home when I get older" or "I would not mind my lifestyle pattern to be tracked by a Health & physiological monitoring system via sensors in my environment.". The Cronbach's alpha of this scale is 0.81. This shows that the internal consistency is good.

Perceived Benefits

Perceived Usefulness

In order to determine the perceived usefulness of different types of monitoring technologies the participants were given a list of different monitoring systems together with examples of monitoring devices that belong to the respective type of technology, for example audio-based technology and smart speakers. They were asked to imagine that they would be monitored by them and based on that rate the technology's usefulness on a 5-point Likert scale ranging from 1 (=totally

disagree) to 5 (=totally agree). The questions were asked in isolation and were not embedded in a specific scenario. There was one item for every type of technology. The types of monitoring technologies were: activities of daily living, instrumental activities of daily living, ambulatory activity, mental functions and physiological activity (Hussain et al., 2019). The Cronbach's alpha of this scale is 0.78, which means that the internal consistency is acceptable.

Expected Benefits of In-Home Monitoring Technology

To measure the participant's view on different benefits of monitoring technologies they had to state, on a 5-point Likert scale from 1 (=totally disagree) to 5 (=totally agree), how much they agree with the benefits listed in the question. In total 14 potential benefits were listed. These were adapted from the study of Wrede et al. (2021). Examples for benefits are "safety at home" and "better self-surveillance and reassurance of safety of patient". The Cronbach's alpha is 0.89, which means that the internal consistency is good.

Perceived Barriers

Privacy and Security Concerns

The participant's privacy and security concerns were measured by letting them state their opinion on 5 statements about privacy and security on a 5-point Likert scale ranging from 1 (=totally disagree) to 5 (=totally agree). Examples for this would be "I am concerned information from these monitoring technologies could be given to people/organizations that do not have a right to it." and "I do not care who has access to information from in-home activity monitoring system.". One item ("I do not care who has access to information from in-home activity monitoring system.") was phrased in reverse and was therefore recoded during the data analysis. The Cronbach's alpha of this scale is 0.83. This means that the internal consistency is good.

Expected Barriers of In-Home Monitoring Technology

To measure the participant's view on different barriers of monitoring technologies they were asked to state how much they agree with the barriers listed in the question on a 5-point Likert scale from 1 (=totally disagree) to 5 (=totally agree). In total 8 potential barriers were listed. These were adapted from the study of Wrede et al. (2021). Examples are "uncertainty of whether to respond to monitoring information", "risk for misuse of data sharing" and "risk of replacing human

contact by technology". The Cronbach's alpha is 0.72. This means the internal consistency is acceptable.

General Perception Towards Technology

General Perception Towards Monitoring Technology

To measure the participant's general perception towards monitoring technology they were asked to rate how controlled they feel by monitoring technologies in their daily life that capture data about them, such as the tracking of their internet browsing history or being filmed by cameras in train/subway stations. The participants had to rate this on a scale ranging from 1 (=not controlled) to 10 (=totally controlled). The Cronbach's alpha of this scale is 0.8. This means that it shows a good internal consistency.

General Trust in Technology

The participants level of trust in technology was determined by 7 statements for which the participants had to rate how much they agree with them. The rating was done on a 5-point Likert scale from 1 (=totally disagree) to 5 (=totally agree). The 7 statements which were adapted from McKnight et al. (2002) and were split into "Faith into General Technology" (4 items) and "Trusting Stance-General Technology" (3 items). One example for the first scale would be "I believe that most technologies are effective at what they are designed to do.". One example for the second scale would be: "I usually trust a technology until it gives me a reason not to trust it.". The Cronbach's alpha of the original scale is 0.90, which means that it shows a good internal consistency. The Cronbach's alpha of the translated version is 0.79. This means the internal consistency is acceptable.

Personal Innovativeness Towards Technology

The personal innovativeness towards technology of the participants was measured by the scale "Personal innovativeness towards technology (PIIT)", which was created by Agarwal and Prasad (1998). This scale consists of three items. One example of this would be "If I hear about a new information technology, I look for ways to experiment with it". The participants were asked to rate how much they agree with them on a 7-point Likert scale ranging from 1 = "Totally disagree" to 7 = "Totally agree". One item ("In general, I am hesitant to try out new information

technologies.") was phrased in reverse and was therefore recoded during the data analysis. The Cronbach's alpha of the original scale is 0.84, which means that it shows a good internal consistency. The Cronbach's alpha of the translated version was 0.87, which means that the internal consistency of the translated questionnaire is also good.

Procedure

The questionnaire was first created in English and then translated once to German by the researcher. This translation was then pretested with three Germans who volunteered to test the questionnaire for readability and clarity. They rated everything as clear and understandable, only a few minor grammar and spelling mistakes were corrected afterwards.

Prior to the start of the data collection ethical approval was given by the BMS Ethics Committee (EC) of the University of Twente on the 11th of April 2021.

After this the questionnaire was distributed via direct messaging on the messaging platform "WhatsApp" by the researcher. The participants were participating voluntarily and did not receive any form of reward or compensation. When they received the online questionnaire, they filled it out individually without the presence of the researcher.

The first page of the survey comprised an informed consent (Appendix B). This gave some general information about the study, such as the aim and the background of the study. Furthermore, it explained the handling of the data and the participant's right of withdrawal. When agreed to this by clicking "I agree", the questionnaire was presented. After completing all questions, which took them on average 15 minutes, the survey ended with the information that the answers were saved successfully and a thank you note.

Data Analysis

For analysing the collected data, the program SPSS (version 25) by IBM was used. First, the data set was sorted out listwise. This means the data from all participants who were under 18 and not German was deleted. Furthermore, all incomplete responses were removed as well. Since all items and scales were translated from English to German Cronbach's alpha was calculated for all of them, in order to test their internal consistency. Furthermore, a Shapiro-Wilk test was conducted in order to test if the assumption of normality is met for all variables.

Next, descriptive statistics were used to analyse the sociodemographic variables age, gender, nationality and digital literacy.

In order to answer the first research question "What is the user acceptance in general of the general German public towards radiofrequency-based in-home monitoring technologies for community dwelling elderlies?" the mean acceptance rating of radiofrequency-based monitoring technologies over all participants was calculated. Additionally, the mean acceptance rating over all participants was also calculated for the technologies "Wearable technology", "Vision-based technology" and "Audio-based technology" to be able to compare the acceptance scores.

To answer the second research question "What is the user acceptance of the general German public in Germany towards in-home monitoring technology for community dwelling elderlies for different monitoring activities?" the mean acceptance rating over all participants was calculated for each monitoring activity.

The third research question was "To what extent are factors from the Technology Acceptance Model (perceived benefits and attitude towards monitoring technologies), perceived barriers and general perception towards technology associated with user acceptance towards radiofrequency-based in-home monitoring technologies for community dwelling elderly according to the general German public?". To answer this, first descriptive statistics were used to calculate the means and standard deviations of all variables in order to further explore the individual variables. Next, a Pearson's correlation analysis was performed between "User acceptance of radiofrequency-based monitoring technologies" and all variables in order to determine if a correlation exists between "User acceptance of radiofrequency-based monitoring technologies" and any of the variables. Furthermore, a Pearson's correlation analysis was also performed between all variables to determine possible relationships between them.

Results

In total 99 people took part in the survey, of which 66 completed the survey and met the inclusion criteria. The age of these 66 participants ranged from 18 to 58 years (M=31.73, SD=13.07). Most of the participants were female (N=50, 76%) and most of them do not have a care role (N=50, 76%). The demographics of the sample are shown in Table 1.

Table 1

Sample Demographics in Frequencies, Percentages, Mean and Standard Deviation

	n	Percent (%)	Mean	SD
Age in years	66		31.7	13.7
Gender				
Female	50	76 %		
Male	16	24 %		
Other	0	0 %		
Digital literacy [1]			7.03	2.01
Care role				
No care role	50	76%		
Providing informal care within own household	3	4%		
Providing informal care outside of own household	2	3%		
Professional caregiver	11	17%		
Receiving informal or professional care	0	0%		

[1] measured on 10-point scale

In order to answer the first research question the mean acceptance rating for radiofrequency-based monitoring technologies over all participants was calculated. The result of this was *M*=2.89 (*SD*= 1.04). This means the average user acceptance of radiofrequency-based home monitoring technologies for community dwelling elderlies is slightly negative. Additionally, the mean acceptance rating for each individual technology was calculated. The highest acceptance was found for the type "wearable technology" (*M*=3.52, *SD*=1.13) and the lowest was found for "audio-based technology" (*M*=2.35, *SD*=0.99). All single scores can be found in Table 2.

To answer the second research question, the mean acceptance ratings for each individual monitoring activity were calculated. The highest acceptance of monitoring was found for the monitoring of "physiological activity" (*M*=3.91, *SD*=1.13), while "activity of daily living" scored lowest (*M*=2.33, *SD*=1.13). All single scores can be found in Table 3.

Table 2

Means and Standard Deviations for Acceptance of Different Types of Technologies Measured on a 5-Point Likert Scale

Type of technology	Examples	Mean Acceptance	SD Acceptance
Wearable Technology	Smartwatches, smart clothing, mobile phones	3.52	1.13
Vision-based Technology	Surveillance cameras	2.74	1.04
Audio-based Technology	Smart speakers	2.39	0.99
Radio Frequency (RF)-based Sensing Systems	Wi-Fi, radar, wireless sensors embedded in daily use objects	2.86	1.04

Table 3

Means and Standard Deviations for Perceived Usefulness and Acceptance of Different Monitoring Activities Measured on a 5-Point Likert Scale

Activity type	Monitored activities	Perceived Usefulness		Acceptance of Different Monitoring Activities	
		Mean	SD	Mean	SD
Activity of Daily Living (ADL)	Eating, Dressing, Washing, Grooming (brushing teeth, washing hand/face and hair dry), Toileting, Sleeping	2.95	1.22	2.33	1.13
Instrumental Activity of Daily Living (IADL)	Meal preparation, Housekeeping, Laundry, Telephone, Medication use	3.64	1.08	3.26	1.15
Ambulatory Activity (AMA)	Dynamic Activities (walking inside-outside and up-down, running, and jogging). Stationary Activities (standing, sitting and lying). Transitional Activities (e.g., sit-to-stand, stand-to-sit, stand-to-walk etc)	3.47	1.06	3.33	1.09
Mental Functions (MF)	Memory, Comprehension, Judgment, Orientation	3.32	1.16	3.15	1.21
Physiological Activity (PHA)	Cardiac Activity, Brain Activity, Muscle Activity, Breathing etc.	3.97	1.11	3.91	1.13

In the context of the third research question “To what extent are factors from the Technology Acceptance Model (perceived benefits and attitude towards monitoring technologies),

perceived barriers and general perception towards technology associated with user acceptance towards radiofrequency-based in-home monitoring technologies for community dwelling elderly according to the general German public?" some interesting outcomes were found. For example, the highest perceived usefulness was found for the monitoring activity "physiological activity" (*M*=3.97, *SD*=1.11) (Table 3). The lowest usefulness was found for "activities of daily living" (*M*=2.95, *SD*=1.22). The full overview can be found in Table 3. Furthermore, it was found that the mean score of expected barriers (M=3.88, SD=0.60) is higher than the mean score of expected benefits (*M*=3.62, *SD*=0.62) (Table 4). The highest score of the benefits was found for "Reassurance about safety of patient" (*M*=4.06, *SD*=0.93). In contrast to that the barrier with the highest scores was "Risk for misuse of monitoring data" (*M*=4.21, *SD*=0.92). A complete overview over all scores can be found in Table 4. A similar result was found when asking for the participant's privacy and security concerns. Here it can be seen that the participants were highly concerned about their data from the monitoring technologies being given to people/organizations that do not have a right to it (*M*=4.23, *SD*= 0.82). A complete overview of all scores can be found in Appendix C, Table C4.

Table 4

Means and Standard Deviations of Expected Benefits and Barriers

	Mean	SD
Expected Benefits		
Better self-care surveillance	3.30	1.04
Eliminating unnecessary in-person control visits	2.88	1.21
Safety at home	3.88	0.87
Detecting and removing factors that hinder independence	3.45	0.96

Helpful for initiating extra care needed	3.83	0.85
Decision support for transition to residential care	3.65	0.83
Supporting objective communication around patient's situation	3.56	0.90
Substantiating diagnostics and indications	3.64	1.02
Responding more quickly to care needs to prevent health risks	4.03	0.76
Improved insight into inhibiting and activating factors of patient's behaviour/ mood	3.39	0.93
Reassurance about safety of patient	4.06	0.93
Regain of freedom and mobility for informal caregiver	3.64	1.03
Providing care at the right times	3.97	0.80

Time gain through remote surveillance of self-care behaviours	3.33	0.88
Expected Barriers		
Risk of feeling monopolized by the system	4.20	0.88
(Un)certainty of whether to respond to monitoring information	3.59	0.84
Risk of disturbing daily work routines	3.02	1.13
Risk for misuse of monitoring data	4.21	0.92
Risk of losing control about data sharing	4.15	0.92
Trade-off privacy infringement versus extended independence	3.64	1.08
Risk of replacing human contact by technology	3.77	1.19
Risk of undermining the formal caregiver's professional view	3.64	1.16

Table 5

Total Scores and Standard Deviations of General Perception of Monitoring Technology, Innovativeness, General Trust in Technology, Privacy and Security Concerns and General Attitude towards Monitoring Technology

Scale	Mean	SD
General attitude towards monitoring technology[1]	3.03	0.70
Privacy and security[1] concerns	4.10	0.80
General perception of monitoring technology [2]	6.55	1.21
Personal innovativeness towards monitoring technology[3]	4.25	1.21
General trust in[1] technology	3.29	0.60

1 measured on 5-point Likert scale

2 measured on 10-point Likert scale

3 measured on 7-point Likert scale

Single scores of all scales can be found in Appendix C

Pearson's correlation analysis showed that a weak correlation exists between "User acceptance of radiofrequency-based home-monitoring technologies" and "Expected benefits" (r=0.27). A moderate correlation was found between "User acceptance of radiofrequency-based home-monitoring technologies" and "General attitude towards monitoring technology" (r=0.36). Additionally, it was found that several variables are correlated with each other, which can be seen in Table 6.

Table 6

Pearson's Correlation between User Acceptance Towards Radiofrequency-Based Home-Monitoring Technology and all Variables

	1	2	3	4	5	6	7	8
1. User acceptance of radiofrequency-based monitoring technology	—							
2. General attitude towards monitoring technology	0.36**	—						
3. Expected benefits	0.27*	0.74**	—					
4. Privacy and security concerns	-0.82	-0.26*	-0.11	—				
5. Expected barriers	-0.17	-0.52**	-0.35**	0.49**	—			
6. General perception towards monitoring technology	-0.01	-0.26*	-0.20	0.38**	0.56**	—		
7. Trust in technology	0.02	0.27*	0.34**	-0.43**	-0.12	-0.20	—	

8. Personal Innovativeness	-0.05	0.13	0.10	0.04	0.04	0.04	0.11	—

$^{*}p < .05$. $^{**}p < .01$.

Discussion

The goal of the first research question of this study was to determine the user acceptance of the general German public towards radiofrequency-based in-home monitoring technologies for community dwelling elderlies. The result of this was that the mean acceptance rating for radiofrequency-based in-home monitoring technologies over all participants is slightly negative. The purpose of the second research question was to find out what the user acceptance of the general German public towards in-home monitoring technology for community dwelling elderlies for different monitoring activities is. The highest acceptance of monitoring was found for the monitoring of "physiological activity", while "activity of daily living" scored lowest. The last research question was "To what extent are factors from the Technology Acceptance Model (perceived benefits and attitude towards monitoring technologies), perceived barriers and general perception towards technology associated with user acceptance towards radiofrequency-based in-home monitoring technologies for community dwelling elderly according to the general German public?". A weak correlation was found between "User acceptance of radiofrequency-based home-monitoring technologies" and "Expected benefits". A moderate correlation was found between "User acceptance of radiofrequency-based home-monitoring technologies" and "General attitude towards monitoring technology". Additionally, it was also found that several variables are also correlated with each other.

Overall, not many studies were conducted about the acceptance of radiofrequency-based home-monitoring systems, since many of these are still in development. However, Mihailidis et al. conducted a similar study to the current study in 2008 where they looked at the acceptance of different home-monitoring technologies, different types of sensors and locations. One of the types of the home-monitoring systems from this study was "Activity of daily living prompting (ADL)", which is measured via radiofrequency-based sensors (Hussain et al., 2019; Mihailidis et al., 2008). The participants were members of the baby-boom generation (aged mostly between 45-49 years)

and community dwelling elderlies (aged mostly between 70-74 years). Their study consisted of a quantitative and a qualitative part in which the participants were asked about the usefulness and their acceptance of the specific monitoring devices and sensors, but also about their acceptance of them in specific rooms.

For "Activity of daily living prompting" measured via radiofrequency-based sensors an acceptance score of circa 60% over all participants was found in both groups, which means the user acceptance is slightly positive. Compared to the acceptance of other types of monitoring technologies, this score was the second lowest acceptance score (Mihailidis et al., 2008). A reason mentioned often by people who did not accept ADL was the lack of perceived need (Mihailidis et al., 2008). In the current study the acceptance of radiofrequency-based monitoring technology was found to be slightly negative, which means that it was lower than in the study of Mihailidis et al. (2008). However, the difference between the current study and the one of Mihailidis et al., (2008) was that in their study they looked at ADL, which is only one specific possibility how radiofrequency-based monitoring technology could be used and the current study looked at radiofrequency-based monitoring technologies in general. So, the comparison of the results of the current study and the study of Mihailidis et al., (2008) is able to give an idea about the acceptance of radiofrequency-based monitoring technologies, but cannot be used for a full comparison. Furthermore, it can be seen that the sample of their study was much older (minimum age 40 years, no mean was given) while the mean age in this study was 31.73 (SD=13.07). This might also contribute to the difference in the acceptance, because younger people (aged between 18-30 years) might have more distance to the topic dementia and caregiving. Another factor that might play a role is that younger people are spending more time in their life using technology, which might give them a different view on technologies and their benefits and barriers. Another factor might be that their study was conducted in 2008 and it is possible that people might have become more acquainted with technology since then, especially also with the barriers that come with it.

Overall, it was found that the factors of the TAM, namely "General attitude towards technology" and "Perceived benefits" were associated with "User acceptance of radiofrequency-based monitoring technology". It was however not found that "Perceived barriers" and "General perception of monitoring technology" are associated to "User acceptance of radiofrequency-based monitoring technology". This does not match the conclusions of Peek et al. (2014) and Safi et al. (2018). In the paper of Peek et al. (2014) they conducted a systematic review of 16 articles in order

to find out which factors are influencing the acceptance of technologies that are supporting aging in place of community-dwelling adults. From this they concluded that "Perceived barriers" are associated with "User acceptance". Most of the articles they studied were focussed on home-monitoring systems (namely vital signs monitoring systems, motion monitoring systems and electronic safety devices), but some also looked at technologies, such as personal alarms or electronic memory aids (= applications or devices that remind people with dementia to conduct certain tasks, such as taking their medication (Alzheimer's Society, n.d.). However, radiofrequency-based monitoring technologies were not covered in these articles. Therefore, the lack of correlation between "Perceived barriers" and "User acceptance" in the current study does not necessarily contradict Peek et al. (2018). Possible causes for the discrepancy might be that most radiofrequency-based monitoring technologies are still in development and not readily available. This might create a certain distance between the participants and the technology. Therefore, they possibly do not know much about this kind of monitoring technology and are not as aware of the barriers as of other more known and already existing kinds of technologies, such as electronic safety devices.

In the study of Safi et al. (2018) a systematic literature review of 52 studies was conducted which looked at factors influencing acceptance and resistance of eHealth technologies in health care. They found that doctors, nurses and patients are more willing to use eHealth technologies, such as eHealth cards or telemonitoring technologies (= "The ongoing assessment of a condition by sensors attached to the patient, signals from which are ported wirelessly to central station or "node" where abnormalities will trigger a response by healthcare workers" (Medical Dictionary, n.d.)) when their general perception of technology is more positive (Safi et al., 2018). However, their study was not exclusively looking at home-monitoring systems, but at all types of eHealth technologies, which might account for the difference that in their study "General perception of technology" was found to be associated with user acceptance and in the current study this was not found to be the case. Furthermore, the participants in the studies Safi et al. (2018) looked at were all health care workers or patients, which means they are actively involved in health care and do not have a distance to it. In comparison to that the current study sample consisted of mostly young people that do not have a care role and therefore are not as involved or acquainted with matters of health care.

Another interesting find in the current study is that the participants are highly concerned about their privacy, especially that their data from the monitoring technologies could be given to/retrieved by people/organisations that do not have the right to it. This was also found in the study of Elers et al. (2018) in which they conducted semi-structured interviews with elderlies (aged 74-92 years) and members of their informal support group (informal caregivers) (aged 20-80 years). The goal of the study was to investigate which technologies connecting the elderly with their support network could be used to increase the elderly's well-being and health and to support aging in place. The results of this study were that all participants generally liked the idea of home-monitoring technologies and showed acceptance for some of the technologies, but it was also visible that information security and privacy were a serious issue for most participants. They were especially afraid that third parties would be able to get access to their data, which is congruent with the results of the current study. Overall, the finding of the study of Elers at al. and this study show that privacy and security concerns are not exclusive to one age group, but it is something that all age groups are concerned about, and which is an important part in their acceptance of a home-monitoring technology. s

Limitations and Strong Points

The limitations of this study were that the German questionnaire was not validated, which means it was not tested if the questions really measure what they are supposed to measure. Additionally, the sample is relatively young, most people do not fulfil a care role and none of the participants is receiving care. Therefore, the sample does not reflect the general German population accurately. So, there is a possibility that the outcome would be significantly different if the sample would have consisted of a more diverse group of people, which would have displayed the general German public more accurately. This might be the case, because in the study of Berridge and Wetle (2020) in which they conducted interviews with elderlies and their adult children about their preferences for three different types of monitoring technologies (location tracking, sensor systems and cameras) it was found that elderlies had relatively different views on the monitoring technologies. This means that the adult children saw most technologies more favourable than their parents (Berridg & Wetle, 2020). This hints towards the possibility that if the sample would have consisted of more elderlies the results might have been different. For example, the acceptance of radiofrequency-based monitoring technology and different monitoring activities might have been

lower. The strong points of this study were that the used scales were found to have an acceptable to good reliability, which means they measure the same to a degree of acceptable or good, as determined through Cronbach's alpha. Furthermore, this study gives a good insight into the perspective of younger people up to age 30. This is the case, because 67% of the sample was 30 years old or younger. The added value of this is that it could be used to compare the outcome of this study to the outcomes of future studies with an older sample.

Practical Implications and Recommendations for Further Research

In this study it was found that the acceptance of radiofrequency-based monitoring systems was slightly negative. However, it would be beneficial to retrieve more insight in why the acceptance was found to be negative. For this it might be useful to conduct a qualitative study with open questions or interviews about the specific reasons and motives people have for not finding radiofrequency-based monitoring systems acceptable. It would be beneficial to use user-centred design in this form in order to increase the likelihood of a successful implementation. This is important to design a monitoring technology that people will actually use and benefit from.

It might also be interesting to conduct another study similar to the current one with an on average older or a bigger and more diverse sample, in order to compare the outcomes to the current study to determine if the outcome would be different and therefore might be dependent on age. Furthermore, it could be checked again if in an older or more diverse sample the factors "Perceived barriers" and "General perception towards technology" are associated with "User acceptance of radiofrequency-based monitoring systems".

In this study, as well as in previous studies (Elers et al., 2018), it seemed like like privacy and data protection issues were a big concern for the participants, because the data collected by the technology is very private and would make the user highly vulnerable in case of a privacy breach. This means that it is of high importance to conduct more research about how to improve the safety and data protection in monitoring technologies. In both of these proposals it is important to use the user centred design, which means to constantly take the future user into account. To ensure this the CeHRes-roadmap could be used. According to van Gemert-Pijnen et al. (2011) the roadmap "serves as a practical guideline to help plan, coordinate, and execute the participatory development process of eHealth technologies". This framework says that the stakeholders should be included

in every step of the design and development process of an eHealth technology and a formative evaluation should take place between every step (Gemert-Pijnen et al., 2011). When following this framework, the end product should be a product which is highly accepted by the users and is going to be used continuously, since the potential users (in this case future informal caregivers and people with dementia) were part of the development process and the product was constantly evaluated.

Overall, home-monitoring technologies appear to have the potential of optimizing the care of people with dementia in terms of increasing the safety and independence of the PwD, so they can stay at home longer and at the same time decreasing the burden of care lasting on the informal caregiver. However, these benefits rely on successful implementation, which is highly dependent on the future development and improvement of home-monitoring technologies. In this process it is important to use user-centred design and frameworks such as the CeHRes roadmap in order to ensure the development of a product which fulfils the needs of the users and that they feel safe and beneficial using. So overall, it is still necessary to conduct further research on this topic in order to increase the acceptance, decrease the barriers and based on this increase the actual usage in the future.

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Appendix A

Survey questions

English version

- What is your age?
- What is your gender?
- What is your nationality?
- Please select what is most applicable to you:
    - I currently provide unpaid care (informal care) to an elderly person (such as, e.g., a spouse, parent, other relative or neighbour) who is part of my household
    - I currently provide unpaid care (informal care) to an elderly person (such as, e.g., a spouse, parent, other relative or neighbour) who lives in his/her own house
    - I currently receive care from my partner/ relatives or receive professional home care.
    - I currently provide professional care to elderly clients.
    - None

Digital literacy

- What are your current digital skills? How well are you able to deal with digital tools? You can give a grade from 1 (very poor) towards 10 (very well).

Level of innovativeness

- How much do you agree with the following statements? You can give a grade from 1 (totally disagree) until 7 (totally agree).

- If I hear about a new information technology, I look for ways to experiment with it
- In general, I am hesitant to try out new information technologies.
- Among my peers, I am usually the first to explore new information technologies
- I like to experiment with new information technologies.

General perception of monitoring technology

- What is your general perception towards monitoring technology for your general activities in your life? You can give a grade from 0 to 10 (0=not controlled – 10=totally controlled).
  - My internet browsing activity
  - My travel activities
  - My internet purchase activity
  - My use of credit cards for payments
  - Being filmed by cameras in train/subway stations
  - Being filmed by cameras in airports
  - Being filmed by cameras while driving on highways
  - Being filmed by cameras while walking down the streets
  - My activity/behaviour as a consumer of certain shops for which I own a fidelity card
  - My activity/behaviour as a consumer of water/gas/electricity, etc.
  - The content of my bag when travelling through airports
  - The files I store on cloud

Perceived usefulness

Type	Activities	Usefulness				
		Totally disagree	disagree	neutral	agree	Totally agree

Activity of Daily Living (ADL)	Eating, Dressing, Washing, Grooming (brushing teeth, washing hand/face and hair dry), Toileting, Sleeping					
Instrumental Activity of Daily Living (IADL)	Meal preparation, Housekeeping, Laundry, Telephone, Medication use					
Ambulatory Activity (AMA)	Dynamic activities (walking inside-outside and up-down, running, and jogging). Stationary activities (standing, sitting and lying). Transitional activities (e.g sit-to-stand, stand-to-sit, stand-to-walk etc)					
Mental Functions (MF)	Memory, Comprehension, Judgment, Orientation					
Physiological Activity (PHA)	Cardiac activity, Brain activity, Muscle activity, Breathing etc.					

Acceptance of monitoring of different types of activities

Type	Activities	Acceptance				
		Totally disagree	disagree	neutral	agree	Totally agree

Activity of Daily Living (ADL)	Eating, Dressing, Washing, Grooming (brushing teeth, washing hand/face and hair dry), Toileting, Sleeping					
Instrumental Activity of Daily Living (IADL)	Meal preparation, Housekeeping, Laundry, Telephone, Medication use					
Ambulatory Activity (AMA)	Dynamic activities (walking inside-outside and up-down, running, and jogging). Stationary activities (standing, sitting and lying). Transitional activities (e.g sit-to-stand, stand-to-sit, stand-to-walk etc)					
Mental Functions (MF)	Memory, Comprehension, Judgment, Orientation					
Physiological Activity (PHA)	Cardiac activity, Brain activity, Muscle activity, Breathing etc.					

Acceptance of different types of technologies

Type	Examples	Acceptance				
		Totally unacceptable	Not acceptable	neutral	acceptable	Totally

						acceptable
wearable technology	e.g. smartwatches, smart clothing, mobile phones					
vision-based technology	e.g. surveillance cameras etc					
Audio-based technology	e.g. smart speakers					
radio frequency (RF)-based sensing systems	e.g. Wi-Fi, radar, wireless sensors embedded in daily use objects					

General trust in technology

Faith in General Technology

1. I believe that most technologies are effective at what they are designed to do.
2. A large majority of technologies are excellent.
3. Most technologies have the features needed for their domain.
4. I think most technologies enable me to do what I need to do.

Trusting Stance—General Technology

1. My typical approach is to trust new technologies until they prove to me that I shouldn't trust them.
2. I usually trust a technology until it gives me a reason not to trust it.
3. I generally give a technology the benefit of the doubt when I first use it

Privacy and security concerns

- I am concerned information from these monitoring technologies could be given to people/organizations that do not have a right to it

- I am concerned information from these monitoring technologies could be given to people/organizations that would use it in a way that would harm you or my relatives.
- I am concerned about privacy in relation to in-home activity monitoring technology
- I do not care who has access to information from in-home activity monitoring system

General attitude towards monitoring technology

- I would not mind being monitored unobtrusively by sensors in my home when I get older
- I would not mind being monitored as long as the data collected is useful for my doctor
- I would not mind my daily activities being tracked by a lifestyle monitoring system.
- I would not mind my lifestyle pattern to be tracked by a Health & physiological monitoring system via sensors in my environment.
- I would like to receive information from the home-monitoring system when there would be a change in the pattern of my activities.
- I would like to receive information from the home-monitoring system when the changes suggest that I might have Alzheimer's disease.
- I would not mind when the system would gather information 24/7

Expected benefits of in-home monitoring technology

Cross-checking self-care information - Better self-care surveillance - Eliminating unnecessary in-person control visits
Extended independent living - Safety at home - Detecting and removing factors that hinder independence - Helpful for initiating extra care needed - Decision support for transition to residential care
Objective communication and substantiation - Supporting objective communication around patient's situation - Substantiating diagnostics and indications

Prevention and pro-active measures - Responding more quickly to care needs to prevent health risks - Improved insight into inhibiting and activating factors of patient's behaviour/ mood
Emotional reassurance - Reassurance about safety of patient - Regain of freedom and mobility for informal caregiver
Personalized and optimized care - Providing care at the right times - Time gain through remote surveillance of self-care behaviours

Expected barriers of in-home monitoring technology

Information overload - Risk of feeling monopolized by the system - (Un)certainty of whether to respond to monitoring information - Risk of disturbing daily work routines
Privacy concerns - Risk for misuse of monitoring data - Risk of losing control about data sharing - Trade-off privacy infringement versus extended independence
Ethical concerns: Dehumanizing care - Risk of replacing human contact by technology - Risk of undermining the formal caregiver's professional view

German version:

- Wie alt sind sie?
- Was ist ihr Geschlecht?

- Was ist ihre Nationalität?
- Bitte wählen sie aus, was am ehesten auf sei zutrifft
    - Ich pflege momentan unbezahlt eine ältere Person (z.B. Partner, Elternteil, andere Verwandte) die Teil meines Haushaltes ist.
    - Ich pflege momentan unbezahlt eine ältere Person (z.B. Partner, Elternteil, andere Verwandte) in einem anderen Haushalt.
    - Ich erhalte momentan Pflege von meinem Partner/Verwandten oder erhalte professionelle Pflege (z.B. von einem Pflegedienst).
    - Ich bin berufliche Pflegekraft.
    - Keine der obengenannten Optionen trifft auf mich zu.

Digital literacy

- Wie hoch ist Ihr Erfahrungslevel mit Technologien/Wie fähig fühlen Sie sich mit Technologien umzugehen? Sie können ihr Level von 1 (sehr niedrig) bis 10 (sehr hoch) bewerten.

Innovationslevel

- Wie sehr stimmen die folgenden Aussagen auf sie zu?

(Definition Informationstechnologien: Informationstechnologie (IT) umfasst alle technischen Ressourcen, die digitale Informationen verwenden, generieren, speichern und archivieren. Außerdem gehört auch die Übertragung der Informationen mittels Kommunikationstechnologie dazu. Beispiele: Computer, Smartphones, Staubsaugeroboter, Glasfaser Internet)

    - Wenn ich von neuen Informationstechnologien höre suche ich nach einem Weg sie auszuprobieren.
    - Ich bin normalerweise eher zurückhaltend gegenüber neuen Informationstechnologien.
    - Ich bin normalerweise die/der erste in meinem sozialen Umfeld die/der neue Informationstechnologien ausprobiert.
    - Ich mag es neue Informationstechnologien auszuprobieren.

Allgemeine Wahrnehmung von Überwachungstechnik

- Wie kontrolliert fühlen Sie sich auf einer Skala von 1 (= nicht kontrolliert) bis 10 (= komplett kontrolliert) wenn Technologien Sie bei den folgenden Aktivitäten überwachen?
    - Mein Internetverlauf
    - Meine Reiseaktivitäten
    - Meine Internetkäufe
    - Meine Kreditkartennutzung für Einkäufe
    - In Bahnhöfen von Kameras überwacht zu werden
    - An Flughäfen von Kameras überwacht zu werden
    - Auf der Autobahn von Kameras überwacht zu werden
    - Mein Konsum(verhalten) in Läden von denen ich eine Treukarte besitze
    - Mein Konsum(verhalten) von Gas/Wasser/Elektrizität
    - Der Inhalt meiner Tasche währen eines Aufenthalts am Flughafen
    - Die Dateien die ich in der Cloud speichere (z.B. Google Drive, iCloud)

- Für welche Art von Aktivitäten wäre es Ihrer Meinung nach nützlich sie zu überwachen? (Angenommen sie würden von ihnen überwacht werden)

Art der Überwachung	Aktivitäten die überwacht werden	Nützlichkeit				
		Stimme gar nicht zu	Stimme eher nicht zu	Neutral	Stimme eher zu	Stimme voll zu
Aktivitäten den täglichen Lebens	Essen, anziehen, sich waschen, Körperpflege (z.B. Zähne putzen, Hände waschen), Toilettenbesuch, Schlafen					
Instrumentelle Aktivitäten	Mahlzeiten vorbereiten, Haushalt, Wäsche waschen,					

des täglichen Lebens	Einnahme von Medikamenten					
Körperliche Aktivität	Dynamische Aktivitäten (z.B. Rennen, gehen, joggen), stationäre Aktivitäten (z.B. sitzen, stehen, liegen), Übergangsaktivitäten (von sitzen zu stehen, von stehen zu sitzen, von stehen zu gehen)					
Mentale Funktionen	Gedächtnis, Verständnis, Urteilsvermögen, Orientierung					
Physiologische Aktivität	Herztätigkeit, Gehirnaktivität, Muskelaktivität, Atmung, etc.					

Akzeptanz der Überwachung von verschiedenen Arten von Aktivitäten

Art der Überwachung	Aktivitäten die überwacht werden	Akzeptanz				
		Stimme gar nicht zu	Stimme eher nicht zu	Neutral	Stimme eher zu	Stimme voll zu
Aktivitäten den täglichen Lebens	Essen, anziehen, sich waschen, Körperpflege (z.B. Zähne putzen, Hände waschen),					

	Toilettenbesuch, Schlafen					
Instrumentelle Aktivitäten des täglichen Lebens	Mahlzeiten vorbereiten, Haushalt, Wäsche waschen, Einnahme von Medikamenten					
Körperliche Bewegungen	Dynamische Aktivitäten (z.B. Rennen, gehen, joggen), stationäre Aktivitäten (z.B. sitzen, stehen, liegen), Übergangsaktivitäten (von sitzen zu stehen, von stehen zu sitzen, von stehen zu gehen)					
Mentale Funktionen	Gedächtnis, Verständnis, Urteilsvermögen, Orientierung					
Physiologische Aktivität	Herztätigkeit, Gehirnaktivität, Muskelaktivität, Atmung, etc.					

Akzeptanz von verschiedenen Arten von Überwachungstechnologien

Art der Überwachung	Beispiele	Akzeptanz				
		Gar nicht akzeptierbar	Nicht akzeptierbar	Neutral	Akzeptierbar	Komplett Akzeptierbar

Wearable Technologien (=Tragbare Technologien)	Smartwatches, Smart-Kleidung, Handys					
Bild-basierte Technologien	Überwachungskameras					
Audio-basierte Technologien	Smart-Lautsprecher					
Radio Frequenz-basierte Sensorsysteme	WLAN, Radar, Kabellose sensoren eingebaut in Objekten des täglichen Lebens					

Vertrauen in Technologien

- Wie sehr stimmen Sie den folgenden Aussagen zu?
    - Ich glaube, dass die meisten Technologien effektiv/wirksam sind in dem wofür sie designed wurden.
    - Die Mehrzahl von Technologien sind großartig.
    - Die meisten Technologien verfügen über die Funktionen, die in ihrem Fachgebiet benötigt werden.
    - Ich glaube dass die meisten Technologien es mir möglich machen zu tun, was ich tun möchte/muss.
- Wie sehr stimmen sie den folgenden Aussagen zu?
    - Meine übliche Herangehensweise ist es, neuen Technologien zu vertrauen, bis sie mir beweisen, dass ich ihnen nicht vertrauen sollte.
    - Normalerweise vertraue ich einer Technologie, bis sie mir einen Grund gibt, ihr nicht zu vertrauen

- Wenn ich eine Technologie zum ersten mal benutze und an ihr zweifele, entscheide ich normalerweise zu Gunsten der Technologie.

Datenschutz & Sicherheitsbedenken

- Wie sehr stimmen sie den folgenden Aussagen zu?
  - Ich bin besorgt, dass Informationen von Überwachungstechnologien an Personen/Organisationen weitergegeben werden könnten, die kein Recht darauf haben.
  - Ich bin besorgt, dass Informationen aus Überwachungstechnologien an Personen/Organisationen weitergegeben werden könnten, die sie in einer Weise verwenden, die mir oder meinen Verwandten schaden würden.
  - Ich mache mir Sorgen aufgrund des Datenschutzes in Bezug auf die Überwachungssysteme.
  - Es ist mir egal wer Zugang zu meinen Informationen von den Überwachungssystemen hat.

Generelle Einstellung gegenüber Überwachungstechnologien

- Wie sehr stimmen Sie den folgenden Aussagen zu?
  - Ich hätte nix dagegen unauffällig/unaufdringlich durch Sensoren überwacht zu werden, wenn ich älter werde.
  - Ich hätte nix dagegen überwacht zu werden, solange es für meinen Arzt nützlich ist.
  - Ich hätte nix dagegen dass meine Aktivitäten des täglichen Lebens durch ein Lifestyle Überwachungssystem verfolgt werden würde.
  - Ich hätte nix dagegen, wenn meine Lebensgewohnheiten von einem Gesundheits- und Physiologie Überwachungssystem durch Sensoren in meiner Umgebung verfolgt werden würde.
  - Ich möchte benachrichtigt werden, wenn das Überwachungssystem eine Veränderung in meinen täglichen Aktivitäten feststellt.
  - Ich möchte benachrichtigt werden, wenn die Veränderungen darauf hindeuten, dass ich eventuell Alzheimer haben könnte.

- Ich hätte nix dagegen, wenn ein Überwachungssystem 24/7 Informationen über mich sammeln würde.

Vorteile von Heimüberwachungstechnologien

- Wie sehr stimmen sie den hier genannten Vorteilen der Überwachungssysteme zu? Bewerten sie auf einer Skala von 1 (Stimme gar nicht zu) bis 5 (Stimme komplett zu.)

Gegenprüfung von Selbstpflege-Informationen - Bessere Überwachung der selbst-Pflege (Self-care) - Eliminierung unnötiger persönlicher Kontrollbesuche
Verlängerung des selbständiges Wohnen - Sicherheit Zuhause - Erkennen und Beseitigen von Faktoren, die die Unabhängigkeit behindern - Hilfreich bei der Einleitung von zusätzlichem Pflegebedarf - Entscheidungshilfe für den Übergang in die häusliche Pflege
Objektive Kommunikation und Begründungen - Unterstützung der objektiven Kommunikation rund um die Situation des Patienten - Begründung von Diagnosen und Indikationen
Prävention und pro-aktive Maßnahmen - Schnelleres Reagieren auf Pflegebedarf, um Gesundheitsrisiken zu vermeiden - Verbesserte Einsicht in hemmende und aktivierende Faktoren des Verhaltens/der Stimmung des Patienten
Emotional reassurance emotionale Vergewisserung - Vergewisserung über der Sicherheit des Patienten - Wiedererlangung von Freiheit und Mobilität für die informelle Pflegeperson (z.B. Partner, Familie, Freunde)
Personalisierte und optimierte Pflege - Bereitstellung von Pflege zum richtigen Zeitpunkt - Zeitgewinn durch Fernüberwachung des Selbstpflegeverhaltens

Erwartete Nachteile in Heimüberwachungssystemen

- Wie sehr stimmen sie den hier genannten Nachteilen der Überwachungssysteme zu? Bewerten sie auf einer Skala von 1 (Stimme gar nicht zu) bis 5 (Stimme komplett zu.)

Informationsüberflutung - Risiko, sich vom System vereinnahmt/kontroliert zu fühlen - (Un-)Gewissheit, ob man auf Überwachungsinformationen reagieren soll - Risiko der Störung der täglichen Arbeitsroutine
Bedenken hinsichtlich der Privatsphäre - Risiko des Missbrauchs von Überwachungsdaten - Risiko, die Kontrolle über die Weitergabe von Daten zu verlieren - Kompromiss: Einschränkung der Privatsphäre im Austausch für verlängerte Unabhängigkeit
Ethische Bedenken: Entmenschlichung der Pflege - Risiko des Ersetzens von menschlichem Kontakt durch Technologie - Risiko der Untergrabung der professionellen Sichtweise des formellen Betreuers

Appendix B

Informed consent

English version:

Informed consent online survey

You are being invited to participate in a research study titled “In-home monitoring technology preferences and expected willingness towards in-home monitoring technology of persons with dementia”. This study is conducted by Annika Köster, student of the University of Twente for her Bachelor thesis.

The purpose of this project is to find out more about the opinions and willingness to use of the general German population towards in-home monitoring systems. Even though you might not be in a situation where you feel the need to adopt such a system (for yourself or others) it is important to still get your input in order to increase our knowledge about the opinions of the whole population in order to design the system in such a way that they are future proof and can be used on future elderlies as well.

Your participation is voluntary and can be revised at any time. There are no known risks associated with this survey. The data of this survey is anonymized, which means the identity of the participants cannot be traced. The collected data will only be used for the purpose of this survey and will be deleted immediately after completion of the bachelor thesis (July 2021).

Study contact for further information:

a.koester@student.utwente.nl

By agreeing to participate you are indicating that: you have read the informed consent and are at least 18 years old.

German version:

Einwilligungserklärung Online Umfrage

Sie wurden eingeladen an der Studie zum Thema der erwarteten Bereitschaft der generellen deutschen Bevölkerung gegenüber Heimüberwachungssystemen für Menschen mit Demenz. Diese Studie wird im Rahmen der Bachelorarbeit von Annika Köster (Studentin der University of Twente, Niederlande) durchgeführt.

Das Ziel dieser Studie ist es mehr über die Meinungen und der Nutzungsbereitschaften der generellen deutschen Bevölkerung gegenüber Heimüberwachunstechnologien herauszufinden. Das bedeutet, auch wenn sie sich (noch) nicht in der Situation sehen, in der sie ein solches System benutzen würden (für sich selber oder für anderen), ist ihre Meinung trotzen wichtig, um diese Technologien in Zukunft so zu designen dass auch zukünftige Generationen von ihnen profitieren können.

Ihre Teilnahme ist freiwillig und kann zu jeder Zeit revidiert werden. Es sind keine Risiken im Rahmen dieser Umfrage bekannt. Die Daten dieser Umfrage sind anonymisiert, was bedeutet die Identität der Teilnehmer ist nicht nachzuvollziehen. Die gesammelten Daten werde nur zum Zweck dieser Umfrage benutzt und werden nach Abschluss der Bachelorarbeit (Juli 2021) umgehend gelöscht.

Bei Fragen bitte diese Emailadresse kontaktieren:
a.koester@student.utwente.nl

Durch das anklicken von “Ich stimme zu” bestätigen sie, dass sie die Einwilligungsbestätigung gelesen haben, eine deutsche Staatsbürgerschaft besitzen und mindestens 18 Jahre alt sind.

Appendix C

Tables Results

Table C1

Means and Standard Deviations of Statements on the General Perception of Monitoring Technologies

Statement	Mean	SD
My internet browsing activity	8.42	1.91
My travel activities	7.18	2.63
My internet purchase activity	8.71	2.20
My use of credit cards for payments	7.71	3.02
Being filmed by cameras in train/subway stations	5.05	2.94
Being filmed by cameras in airports	5.15	3.10
Being filmed by cameras while driving on highways	4.76	2.77
My activity/behaviour as a consumer of certain shops for which I own a fidelity	6.64	2.77

card		
My activity/behaviour as a consumer of water/gas/electricity, etc.	4.85	2.97
The content of my bag when travelling through airports	5.77	3.34
The files I store on cloud	7.76	2.51

Table C2

Means and Standard Deviations of Statements on Personal Innovativeness Towards Technology

	Mean	**SD**
If I hear about a new information technology, I look for ways to experiment with it.	4.48	1.29
In general, I am hesitant to try out new information technologies.	3.44	1.41
Among my peers, I am usually the first to explore new information technologies.	3.27	1.58

I like to experiment with new information technologies.	4.67	1.45

Table C3

Means and Standard Deviations of Statements on General Trust in Technology

Statement	**Mean**	**SD**
I believe that most technologies are effective at what they are designed to do.	3.67	0.83
A large majority of technologies are excellent.	3.44	0.86
Most technologies have the features needed for their domain.	3.64	0.69
I think most technologies enable me to do what I need to do.	3.73	0.87
My typical approach is to trust new technologies until they prove to me that I shouldn't trust them.	2.77	1.09
I usually trust a technology until it gives me a reason not	3.23	1.04

to trust it.		
I generally give a technology the benefit of the doubt when I first use it.	2.56	0.90

Table C4

Means and Standard Deviations of Statements on Privacy and Security Concerns

Statements	Mean	SD
I am concerned information from these monitoring technologies could be given to people/organizations that do not have a right to it.	4.23	0.82
I am concerned information from these monitoring technologies could be given to people/organizations that would use it in a way that would harm you or my relatives.	3.86	1.05
I am concerned about privacy in relation to in-home activity monitoring technology.	3.85	1.01
I do not care who has access to information from in-home activity monitoring system.	1.68	1.01

Table C5

Means and Standard Deviations of Statements about General Attitude towards Monitoring Technology

Statement	Mean	SD
I would not mind being monitored unobtrusively by sensors in my home when I get older.	2.95	1.12
I would not mind being monitored as long as the collected data is useful for my doctor	3.58	0.84
I would not mind my daily activities being tracked by a lifestyle monitoring system.	2.35	1.06
I would not mind my lifestyle pattern to be tracked by a Health & physiological monitoring system via sensors in my environment.	2.83	1.06
I would like to receive information from the home-	3.35	1.14

monitoring system when there would be a change in the pattern of my activities.		
I would like to receive information from the home-monitoring system when the changes suggest that I might have Alzheimer's disease.	3.23	1.04
I would not mind when the system would gather information 24/7	2.08	0.99

Table C6

Means and Standard Deviations of Expected Benefits and Barriers

	Mean	SD
Expected Benefits		
Better self-care surveillance	3.30	1.04
Eliminating unnecessary in-person control visits	2.88	1.21
Safety at home	3.88	0.87
Detecting and removing factors that hinder independence	3.45	0.96

Helpful for initiating extra care needed	3.83	0.85
Decision support for transition to residential care	3.65	0.83
Supporting objective communication around patient's situation	3.56	0.90
Substantiating diagnostics and indications	3.64	1.02
Responding more quickly to care needs to prevent health risks	4.03	0.76
Improved insight into inhibiting and activating factors of patient's behaviour/ mood	3.39	0.93
Reassurance about safety of patient	4.06	0.93
Regain of freedom and mobility for informal caregiver	3.64	1.03
Providing care at the right times	3.97	0.80

Time gain through remote surveillance of self-care behaviours	3.33	0.88
Expected Barriers		
Risk of feeling monopolized by the system	4.20	0.88
(Un)certainty of whether to respond to monitoring information	3.59	0.84
Risk of disturbing daily work routines	3.02	1.13
Risk for misuse of monitoring data	4.21	0.92
Risk of losing control about data sharing	4.15	0.92
Trade-off privacy infringement versus extended independence	3.64	1.08
Risk of replacing human contact by technology	3.77	1.19
Risk of undermining the formal caregiver's professional view	3.64	1.16